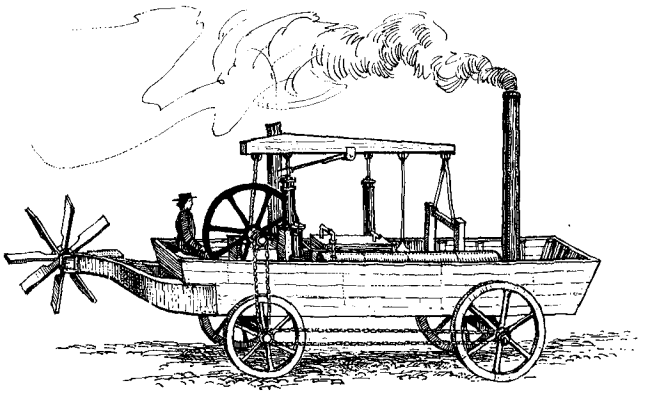
EARLY DREDGING

Masters of vessels plying the Delaware River and Bay in the 17th and 18th Centuries compiled navigation logs compounded of weather instinct, seamens' rumors and much swinging of the lead. Some reliance may have been placed on such charts as were available; Joshua Fisher's charts, variously dated, and the river and bay maps of Francis Shallus labeled the natural channels and indicated bottom contours and soundings in a broad, general manner. One of Fisher's charts, dated 1776, bore the endorsements of 44 pilots and masters of vessels as the only dependable chart available. Certainly, the shoals had a pattern of inconstancy and ship routes were alternately obliterated and restored by the endless cycle of tides and currents. Captains of ships sought safe anchorages along the estuary to wait for the tide that would bear them up to Philadelphia, navigating by the efficacy of their seamanship and faith in their leadsmen.

Noteworthy activity in the pursuit of channel dredging in the Delaware River coincided with the advent of steam-powered equipment. Muscle-powered dredging, practiced for centuries in Holland and Italy, was becoming obsolete at about the time the Delaware's deep hulls began to require the establishment and maintenance of disciplined, reliable channels. A Dutch-type mud mill was built for the Board of Port Wardens of Baltimore around 1784 and put to work deepening that harbor; the mud was raised by long-handled spoons, operated by man-powered treadmills. Delaware River mud[1] was dealt with in 1803 at New Castle Harbor when the Engineer Department installed the first ice pier there, and again within a few years, when mud nearly filled the harbor. Some dredging was done, presumably man-powered. In 1804, Oliver Evans equipped a "carriage" with a steam engine and stern paddle wheel and operated it, first on High Street, Philadelphia, then in the Schuylkill and Delaware Rivers. Its purported function was channel clearance. This "*Orukter Amphibolos*" was probably the first mechanically-powered dredge to operate in the Delaware. Evans described it as "a large flat, or scow, with a steam engine of the power of five horses on board to work machinery to raise the mud into flats."

Especially relevant to the chronicle of an industry is the related status of general technological development. Prior to the availability of mechanical power sources, the dredging of streams and harbors was laborious, slow and minimally effective. Channel clearance was largely a matter of moving the obstructing material from one place to another in the stream. Stirring and scraping devices were employed in estuaries where, hopefully, suspended particles of the shoal would find their way to deep water, transported on the ebbing tide[2]. With steam dredges it became feasible to retain and transport a greater percentage of the excavated fines, but until the hydraulic pipeline dredge came into use, deposit of dredge spoil on land sites was awkward and expensive; therefore, the mud scows were towed long distances and emptied into the bay or into "holes" in the river bottom. Solutions requiring minimum channel maintenance were projected in terms of structures which modified the channel section and induced a measure of self-maintenance through the scouring of tides and currents. A program for construction of channel training dikes was curtailed in 1885, after some effective diking



The amphibious digger, constructed by Oliver Evans for the Philadelphia Board of Health in 1804, was the first wheeled vehicle to move under its own power in America. It was also the first mechanically powered dredging apparatus to operate in the Delaware River.

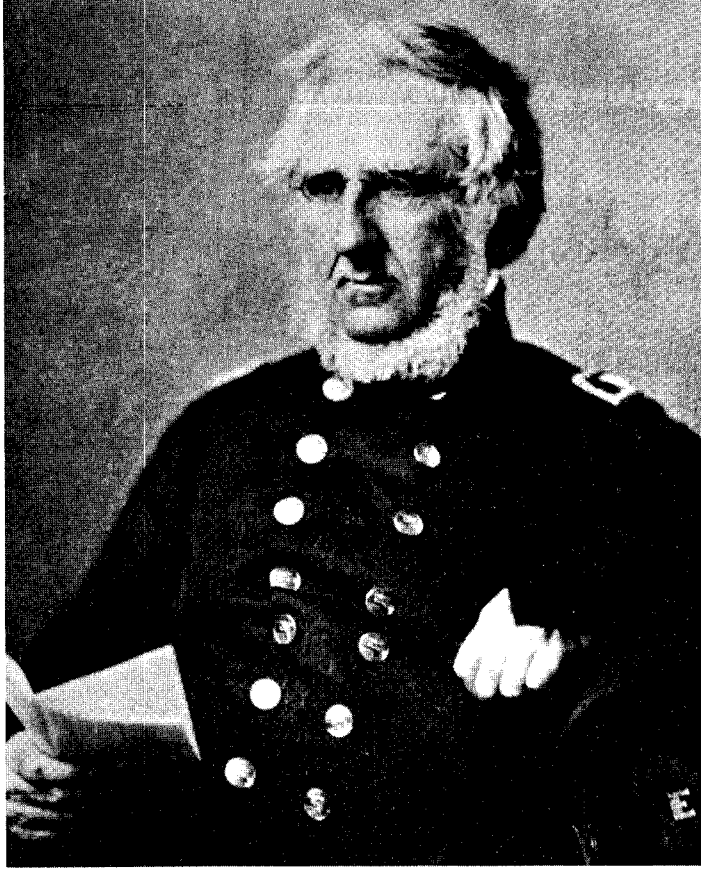
had been done; maintenance planning was subsequently oriented toward dredging, since a greatly expanded capability tended to make that technique more economically favorable.

In the early years of the Nineteenth Century, when Delaware channel depths of 12 to 27 feet provided adequate draft for most of the craft then plying the river, dredging was performed primarily to clear the harbors of New Castle, Wilmington, Chester and Marcus Hook. Mud and sand were the materials requiring removal. Dredging equipment was steam-powered by 1829, possibly earlier. In that year Congress provided an appropriation for procurement of a "*dredging machine to be applied to the deepening of the Delaware River Harbors.*" A similar appropriation had been granted in 1827 for a steam dredge boat to remove shoals at Ocracock Inlet, North Carolina. Specified as an experiment, this dredge was not put into operation until August 1830, due to difficulty experienced by the contractor in completing the machinery

It is clear that the Ocracock apparatus was a form of ladder dredge, which successfully performed the experiment by providing a channel through the sand bar to a depth of about 10 feet of water. The Delaware unit was operational in 1831; a hired machine worked the Delaware harbors in the summer of 1830. Although not clearly specified, this equipment probably was similar in design and function to that constructed for the Ocracock experiment. The ladder dredge, of European provenance, served the initial purposes of mechanically powered excavation, but was superseded in America by the more versatile and less costly grapple and dipper dredges. According to the Chief Engineer's report for 1831, the dredging operations were the only works of improvement undertaken that year in Delaware River Harbors. Operations continued through 1832, with Port Penn added to the harbor dredging schedule. Only Marcus Hook received the benefits of the steam dredge in 1833, when 15,369 cubic yards of earth were removed, "to form a safe and secure retreat for about 20 sail of vessels."

In 1835, Captain Richard Delafield reviewed the conditions of Delaware River Harbors since 1789 and made some cogent recommendations. He advised installation of additional free-standing piers, extending the harbors toward the greater depth of the stream to achieve increased harbor capacity. Thus, the outer portion of the harbor would maintain a stable depth through the action of the tides and currents, which would be only minimally deterred by the tapered piers. A system of sluiceways penetrating the wharves and land fast piers would effectively circulate water and thwart accumulation of mud in the inner harbors. Captain Delafield further recommended that dredging of the harbors be abandoned as "it is not deemed advantageous towards effecting the desired object, or, when accomplished, answering a permanent good."

An attempt was made to improve Delaware navigation in 1836 by authorizing dredging in Wilmington Harbor. A steam dredge removed 5,000 cubic yards of material from the bed of Christina River and placed it on dikes at the river margin. Concurrently, $15,000 was appropriated for improving the harbor at Philadelphia by removal of Mifflin Bar. On receipt of the assignment, Captain Delafield noted that no survey had been made, or plan suggested. He conducted a survey of the bar and an investigation of its history and deter-



Major General Richard Delafield

—National Archives

mined that it could be traversed in 16 to 21 feet of water, depending on the tide, and that it presented no obstacle to the largest class of merchantman. River pilots stated that depths over the bar were greater than they had ever before known them and that the whole mass of the bar had shifted 300 yards northward in the past two years. Summing up his "*memoir,*" Captain Delafield pointed out the risk, by removal of Mifflin Bar, of creating mud flats to replace a navigable water course, and stressed the futility of attempting removal of a constantly shifting mass of material; "I cannot too strongly recommend that, in this instance, nature be left to work for herself, unaided by art."

Forty-four years elapsed before Mifflin Bar was attacked by the dredges. Richard Delafield's firm and appropriate decisions would earn for him the highest rank and rewards achievable in the Engineer Department of the Army. Steam dredge boats owned by the Government operated sporadically in the waters of the Delaware River and its tributaries in the 1840-50 period; inactivity made their maintenance an expensive burden; locally based units of dredging equipment were sold to commercial salvage companies. Meanwhile, Government dredge boats were employed on the Great Lakes and in estuaries of the Middle Atlantic Coast, where mud and sand shoals impeded the navigation of even very shallow draft vessels. The "*Lavaca,*" built at Louisville, Kentucky in 1845 by order of Colonel Stephen Long of the Topographical Engineers, was the prototype of the period's capability in steam-powered dredging. Equipped with two dredge ladders and four mud scows, she could remove 150 cubic yards of mud or sand per hour to a depth of 10 feet and propel herself at eight miles per hour. Congress authorized construction of a similar unit in 1847, another in 1852.

The Delaware River, swift and wide, continued to provide a natural channel adequate to the needs of navigation. The Engineer Department concentrated on military matters; in 1849 its total complement of officers numbered 49, of whom 30 were concerned with construction and repair of fortifications, nine were at the Military Academy at West Point and two in the Engineer Department Office in Washington. Eight officers were on survey missions across the country or on detached duty with other military departments. It was in the context of national defense that a system for improving navigation was recommended in 1853. Major Delafield, superintending projects for Atlantic Coast defenses, proposed a combination of dredging with ladder dredges and diking the stream banks, the dredged spoil to be dumped behind the stone-filled timber dikes. The system contained the basic formula for channel dredging which continued in practice long

Major General Andrew A. Humphreys

—National Archives

after ladder dredges disappeared from the Delaware estuary.

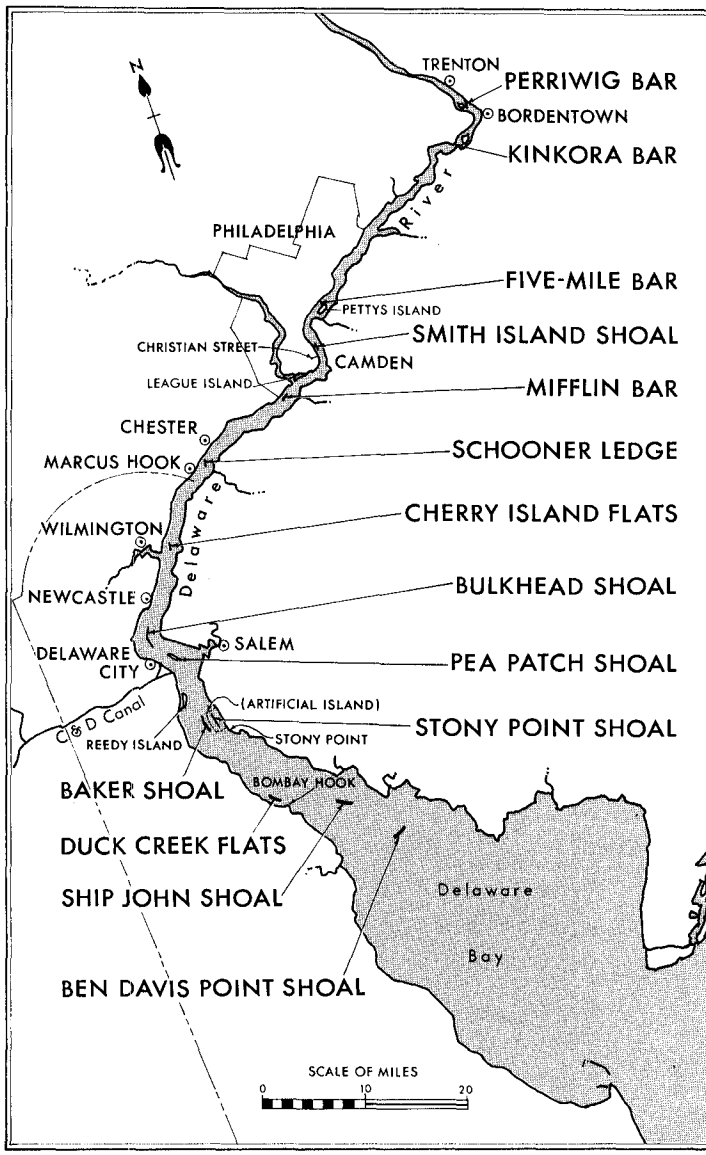
Aids to navigation in the District area in the decade preceding the Civil War were those afforded by the ice harbors and the Breakwater Harbor in Delaware Bay. The post war decade witnessed a phenomenal expansion of trade and industry and a prodigious increase in maritime taffic for Philadelphia, second largest port in the nation. International shipping lanes traversed the waters of Delaware River and Bay and harbor planners envisioned an established ship channel of fixed dimensions with permanent maintenance facilities. The 1866 reorganization of the Corps of Engineers, structured on watershed systems and oriented toward water resources planning, definitely abetted the prospects of Delaware channel improvement.

In 1878, deep water vessels had a draft of 20 to 24 feet, loaded. There were places where ships could ground in the Delaware channel without benefit of a full tide. One such hazard was at Schooner Ledge, 18 miles below Philadelphia between Chester and Marcus Hook. Schooner Ledge was a rock reef extending from the Pennsylvania shore like a submerged dam or bulkhead of irregular height, which, according to Captain Ludlow, "could be regarded as the most dangerous if not the most serious obstruction in the river."

Rock excavation of Schooner Ledge began in 1879 in the costliest single project yet undertaken for the improvement of Delaware River navigation. Since 1836, when navigation improvement was begun, channel clearance had been achieved only by dredging, using the various techniques which the currently prevailing technologies afforded. The first rock removal was at Schooner Ledge, for which drilling was begun in October, 1879. The initial project required the cut across the ledge to bottom at 24 feet, mean low water. The drill platform, of heavy yellow pine timbers, stood above high tide on four yellow pine spuds; two Burleigh drills, track-mounted, were moved across the platform by a rack-and-pinion device. The rig drilled three-inch diameter holes for the blasting charges; material was removed by dipper dredge.

Colonel Macomb, under whose orders the District operated between 1877 and 1882, wrote deploringly in 1880 of dredging contractors who dumped dredged material back into the river. A considerable amount of dredging was done throughout the tidal section of the Delaware, from Bordentown, N.J., where the entrance of the Delaware and Raritan Canal had been obstructed by a sand bar, to Duck Creek, Delaware, where the creek's entrance across the flats was dredged to a depth of eight feet. In between, much larger works were in progress: Cherry Island Flats, opposite the mouth of Christina River, were bisected by a channel from which 1.5 million cubic yards were dredged; in the broad curve of the river below New Castle, Delaware, a 24-foot channel was started through Bulkhead Shoal on a mile-long axis. Dredging continued at Pettys Island and Mifflin Bar and the problem of spoil disposal began to loom as a serious predicament. For several years the government land at Fort Mifflin and League Island had served as repositories for channel dredgings. As these would soon be filled, Colonel Macomb and Captain Ludlow cast about for new dumping sites.

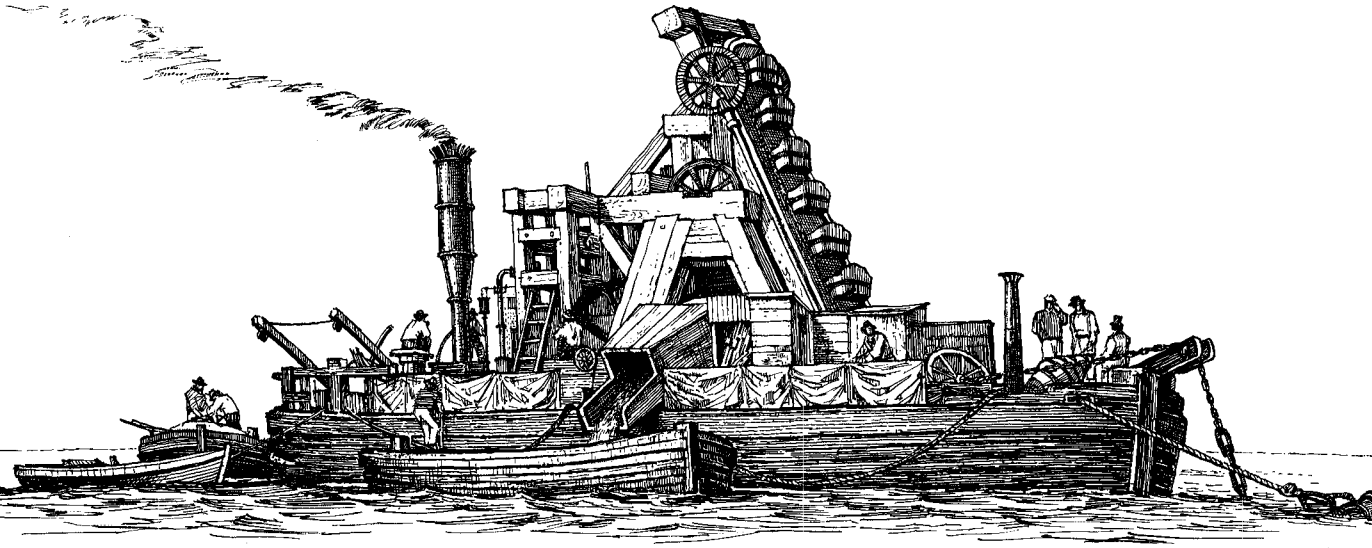
Long stretches of the Delaware River maintained a natural low water depth of about 27 feet. These navigable reaches were interrupted by more or less perilous obstacles where shoaling occurred in repetitive, natural patterns. The bars, shoals and flats named and located here were regularly cited for dredging appropriations during the years when a 27-foot depth of channel was considered an ultimate goal. Baker and Stony Point Shoals were bulkheaded to create a disposal area (Artificial Island) when excavation was begun for the 30-foot channel in 1900.



An experiment seeking an alternative to overboard disposal was proposed by Colonel Macomb and conducted at Fort Mifflin in 1879. Dredged spoil was deposited in rehandling basins dug adjacent to a land-based, diked inclosure; the material was then redredged into dump cars, moved on tracks along the top of the dikes and dumped on the inclosed lands. Colonel Macomb headed a special board appointed by General Humphreys in July 1879 to report on the future prosecution of Delaware channel improvement.[3]

The Board found the dumping of dredged materials within the tidal limits of the river to be deleterious to navigation and against the spirit of existing State laws, as the "fluid and yielding material" tended to be redistributed and returned to the channel. Most significant was the Board's statement that "the present and probably ultimate greatest available depth that can be maintained for the navigation of the Delaware River is about 27 or 28 feet at mean low water. For long stretches of many miles of main channel the existing and possible depths do not exceed these, while the actual draught required for the commerce of the river is not in excess of 25 feet." The Board recommended "*that dredged material be deposited ashore behind dikes or bulkheads or upon land beyond the reach of the tides, where requisite authority is obtained or where the privilege may be purchased at a small and reasonable price per acre.*"

The Board's sincere and laudable concern brought about no immediate revision of policy in the prosecution of Delaware River dredging. Available land sites were difficult to find and riparian owners demurred at the obligation to finance the erection of dikes and bulkheads. There was a marked decline in the number of proprietors who regarded the dumping of dredged spoil on their lands as beneficial, still less as an enhancement of real estate values for which they should incur expense. Potential disposal areas beyond a stipulated maximum of 25 miles from the excavation site were considered impractical because of haulage costs; 25 miles was also regarded as the maximum range for convenient utilization of the tide in towing mud scows. The concept of an ultimate channel depth of 27 to 28 feet, based on the mean depth of the natural channel, presumed limited use of the estuary in terms of ships sizes; it also implied a predictable average volume maintenance dredging requirement.



The mud dredger of the 1830's was best exemplified by the steam-driven endless chain bucket or ladder dredge. This type retained the favor of the Europeans, but was replaced in American waters by grapple and dipper dredges.

Concepts were drastically revised by 1885, when legislation was enacted to authorize the permanent improvement of Delaware River and Bay. Since then, a succession of projects has progressively increased the depth of the navigation channel, keeping pace with the requirements of commercial traffic. (Ultimate channel depth limits were again discussed in the early 1970's, as new, gigantic hulls entered the maritime service; alternatives to traditional river traffic were studied, in the form of deepwater terminals, pipelines and shallow draft shuttle craft.)

By 1890, the scarcity of disposal areas was acute. Major Raymond, then starting a 10-year tour of duty as Philadelphia District Engineer, took vigorous charge of navigation improvement with its vexatious spoil disposal problems. A solution of sorts was achieved by making spoil disposal a responsibility of the dredging contractors. Surveys were made in quest of "secondary channels of relatively small importance and other suitable places in the bed of the river" in which spoil could be dumped. A tremendous volume of material had to be excavated from the Philadelphia Harbor area; government lands at Fort Mifflin and League Island were convenient and capable of receiving about half of the dredge material, but in 1895 the Navy Department blocked a proposed extension of authority to continue the depositing of spoil at the League Island Navy Yard site. In the six years following Major Raymond's assignment to the District, approximately 10.7 million cubic yards of dredged material were dumped on the river at nine different locations.

The River and Harbor Act of 3 June 1896 authorized a survey for the creation of a 30-foot channel from Philadelphia to Delaware Bay. The survey covered 56 miles of proposed channel between Christian Street, Philadelphia and a point just below Bombay Hook. Estimated cost of the project was $5,810,000. Prices were based on dredging by dipper and grapple dredges — hydraulic dredging was thought to be limited and uncertain. The amount of material to be removed by dredging was estimated at 34,953,000 cubic yards plus excavation of 24,000 cubic yards of rock. Six locations were earmarked under the heading "Places of Deposit," with the capability of receiving at least four-fifths of all material excavated. Three were on government-owned land adjacent to Forts Delaware, Mott and Dupont; a fourth was to be located along Wilmington's Delaware River shore just above the Christina River. Specific authority was provided for the creation of a large disposal area below Reedy Island on the

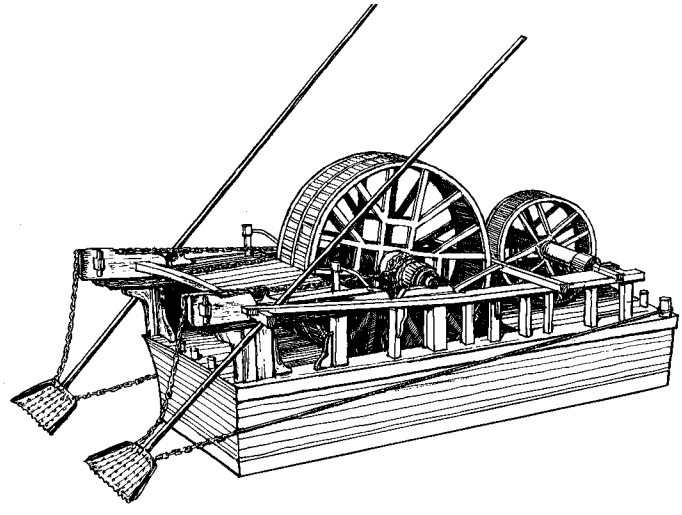
eastern side of the river. At the site, Baker Shoal and Stony Point Shoal were to be inclosed by bulkheads to form the principal deposit basin in the Lower Delaware, known since as Artificial Island. A sixth location cited by the Survey Board was in Delaware Bay — "a deep hole below Ben Davis Point Shoal."

Initial appropriations for the 30-foot channel were designated for removal of the shoal below Reedy Island, "now the most troublesome obstruction to the navigation of the river," and for construction of bulkheading for the proposed artificial island disposal area. This work was begun with pile-driving for the bulkhead on 4 April 1900.

A great many dredging operations were active in the District as continuing projects around the turn of the century. The improvement of Wilmington and Philadelphia harbors went forward. Navigation channels were provided for a number of the Delaware's tributary streams, while improvement surveys were underway for others. Maintenance operations on the river did not consist solely of dredging the channel; removal of wrecks kept salvage firms occupied in all seasons. The wreckage of sunken derelict vessels imperiled navigation, both as hazardous obstacles to shipping, and as possible nuclei for the build-up of obstructive shoals. Before 1881, dredgemen under contract for removal of wrecks were required to surrender salvaged cargoes to the Engineer Department for disposal at auction. The revised policy, allowing contractors to retain salvage, resulted in keener competition, lower bid prices and more thorough clean-up of wreckage.

The craft of dredging was maturing rapidly; hydraulic systems, with improved cutters and pumping plants, were increasingly used to supplement or supplant the old reliable dipper and grab dredges. The U.S. Government built its first hopper dredge in 1890; three more before 1900. Fourteen hopper dredges were completed or under construction by the government in the intensive construction period between 1901 and 1904.

Dredging was no longer a primitive craft, nor yet an exact science; but it had become an established, key function in the growth and development of the maritime community. Community expansion and the availability of more refined tools had led to the realization that dredging was essential to the economic health of the region.



This type of mud mill or spoon dredge was used to deepen Baltimore Harbor. The two treadmills were rotated by manpower.